Age-related inequalities in colon cancer treatment persist over time: a population-based analysis

Age-related inequalities in colon cancer treatment persist over time: a population-based analysis

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ABSTRACT

Background Older people experience poorer outcomes from colon cancer. We examined if treatment for colon cancer was related to age and if inequalities changed over time.

Methods Data from the UK population-based Northern and Yorkshire Cancer Registry on 31 910 incident colon cancers (ICD10 C18) diagnosed between 1999–2010 were obtained. Likelihood of receipt of: (1) cancer-directed surgery, (2) chemotherapy in surgical patients, (3) chemotherapy in non-surgical patients by age, adjusting for sex, area deprivation, cancer stage, comorbidity and period of diagnosis, was examined.

Results Age-related inequalities in treatment exist after adjustment for confounding factors. Patients aged 60–69, 70–79 and 80+ years were significantly less likely to receive surgery than those aged <60 years (multivariable ORs (95% CI) 0.84(0.74 to 0.95), 0.54(0.48 to 0.61) and 0.19(0.17 to 0.21), respectively). Age-related differences in receipt of surgery and adjuvant chemotherapy (but not chemotherapy in non-surgical patients) narrowed over time for the 'younger old' (aged <80 years) but did not diminish for the oldest patients.

Conclusions Age inequality in treatment of colon cancer remains after adjustment for confounders, suggesting age remains a major factor in treatment decisions. Research is needed to better understand the cancer treatment decision-making process, and how to influence this, for older patients.

INTRODUCTION

Colorectal cancer is the third most commonly diagnosed cancer in men and women in the UK[1] and globally.[2] Survival from colon cancer worldwide is worse in those aged ≥65 years,[3] despite >70% of cases occurring in this age group.[1] In addition, a survival deficit has been identified in the UK compared with countries with the highest cancer survival (Australia, Canada, Norway and Sweden). Both 1-year and 5-year survival for colorectal cancer are 8%–10% lower in the UK than in countries with the highest survival, and this increases to a 10%–15% difference for those aged ≥65 years.[3] There is evidence that the gap in colorectal cancer survival between older and younger patients widened between 1988–1990 and 1997–1999 across Europe in women, although narrowed slightly during the same time period in men.[4] There was lower survival in the UK compared with five other countries with similar levels of healthcare access, included in the International Cancer Benchmarking Partnership, and this was more pronounced in older (aged 70–99 years) patients.[5] Age-related variation in survival is much less marked in the USA than in Europe and has been attributed to earlier diagnosis and more aggressive treatment in the USA.[6] It has been suggested that in several countries, including the UK, elderly patients with cancer are undertreated compared with younger patients,[7–9] and that this unequal access to treatment in practice, despite universal access in theory, accounts for at least some of the reported survival difference.[5]

Previous work suggests that elderly patients are significantly less likely to receive adjuvant therapy for colon cancer.[10 11] It has been observed that elderly patients who survive 1 year after diagnosis of cancer have a similar 5-year prognosis to middle-aged patients,[4] suggesting that elderly patients who are in sufficiently good health to withstand treatment can derive similar benefits to younger patients. Determining the best course of cancer treatment for elderly people, a population that is heterogeneous in terms of health status and degree of frailty, is difficult for clinicians.[12] Comorbidities, poorer health status and cancer stage at diagnosis, as well as patient preferences, may be valid reasons for not offering aggressive treatment to frail, older patients.[13] However, many epidemiological studies of patterns of treatment by age fail to account for these factors.

A better understanding of age-related inequalities in treatment of colon cancer would help to inform interventions to improve cancer control. We undertook a population-based study to investigate if there are age-related inequalities in colon cancer care in the North of the UK, taking into account comorbidity and other confounders and, if so, if these inequalities have changed over time.

METHODS

Data sources

Data on age, sex, area deprivation (as a proxy for socioeconomic status (SES)), year of diagnosis, tumour site and stage and treatments received (cancer-directed surgery and chemotherapy) were obtained for all patients diagnosed with colon cancer (ICD10 C18) between 1 January 1999 and 31 December 2010 from the population-based Northern and Yorkshire Cancer Registry (NYCRIS). NYCRIS covers a population of 6.8 million people. Hospitals mandatorily report cases of cancer directly to NYCRS. Extensive quality assurance of the register is performed.[14] Information on treatments received until 31 December 2011 was available (ie, 12 months after the latest date of diagnosis).

Each record was linked to UK National Health Service (NHS) Hospital Episode Statistics (HES) data to provide information on comorbidities. All admissions, outpatient appointments and A&E attendances at NHS hospitals in England are recorded in HES data. NYCRIS supplied the linked and anonymised data to the authors.

Outcome variables

The outcome variables of interest were chosen to reflect current colon cancer treatment guidelines[15 16]: receipt of cancer-directed surgery compared with no cancer-directed surgery (n=31 910 patients included in the analysis), receipt of chemotherapy in surgical patients (n=24 263), receipt of chemotherapy in non-surgical patients (n=7647) and receipt of no cancer-directed treatment (ie, no surgery, chemotherapy or radiotherapy; n=31 910).

Explanatory variables

Age at diagnosis was categorised into <60, 60–69, 70–79 and 80+ years. Linearity of the relationship between age and outcomes was checked and it was appropriate to group age in this way for the analyses.

Area deprivation was measured using the rank of the income domain of the Index of Multiple Deprivation (IMD), grouped into quintiles, based on the distribution across England, with quintile 1 representing the most affluent areas and quintile 5 the highest level of deprivation.[17] Year of diagnosis was categorised into three equal sized groups for ease of presentation and interpretation: 1999–2002, 2003–2006 and 2007–2010. Cancer stage was assigned using the TNM staging system[18] and categorised as I, II, III, IV, unstaged or staged post-treatment. NYCRIS provided a weighted comorbidity score based on the Charlson comorbidity index (CCM),[19] which provides a count of the number of relevant in-patent admissions (excluding metastatic cancer) recorded in HES data in the time period 3–18 months prior to the colon cancer diagnosis. The comorbidity score was categorised as 0, 1–2 or 3+ comorbid conditions resulting in an inpatient episode for ease of interpretation.

Statistical analyses

Cases registered on the basis of a death certificate only were excluded (n=495). In the remaining cases, the distribution of receipt of cancer-directed treatment (surgery, chemotherapy in surgical patients, chemotherapy in non-surgical patients and no treatment) by age, sex, SES, period of diagnosis, stage and CCM was examined. As chemotherapy is not an appropriate treatment in early stage colon cancer, analyses were repeated, restricted to stage III and IV cancers.

Univariable and multivariable logistic regression models were used to examine the likelihood of receipt of each of the treatment outcomes by age group with and without adjustment for covariates. Trends in likelihood of receipt of treatment by age over time were examined. Interaction between age and time period of diagnosis was tested by fitting a cross-product term and comparing, using the likelihood ratio test, the model with the cross-product term and nested model without the cross-product term. For ease of interpretation, the results presented here show risk estimates for age group, stratified by period of diagnosis. In addition, graphs showing the marginal effects of the interaction terms are included as an online supplementary web figure.

Stata V.14.0 was used for all analyses.

Table 1 Demographic and clinical characteristics of cohort with colon cancer (n=31 910)

	n (%)
Age group, years	
<60	4556 (14.3)
60–69	7377 (23.1)
70–79	11 086 (34.7)
80+	8891 (27.9)
Sex	
Female	15 212 (47.7)
Male	16 698 (52.3)
Deprivation quintile	
1 (least deprived)	5682 (17.8)
2	6150 (19.3)
3	5990 (18.8)
4	6711 (21.0)
5 (most deprived)	7377 (23.1)
Period of diagnosis	
1999–2002	9860 (30.9)
2003–2006	10 424 (32.7)
2007–2010	11 626 (36.4)
Stage	
I	2782 (8.7)
II	9107 (28.5)
III	7738 (24.3)
IV	7712 (24.2)
Unstaged	4440 (13.9)
Stage PT	131 (0.4)
CCM	
0	22 486 (70.5)
1–2	2976 (9.3)
3+	700 (2.2)
No HES link	5748 (18.0)
Treatment	
Any surgery*	24 263 (76.0)
Surgery+chemotherapy†	7736 (31.9)
Chemotherapy alone‡	1589 (20.8)
None*	6058 (19.0)

*Proportion is of all patients with colon cancer (n=31 910).
†Proportion is of all patients with colon cancer who had surgery (n=24 263).
‡Proportion is of all patients with colon cancer who did not have surgery (n=7647).
CCM, Charlson comorbidity index; HES, Hospital Episode Statistics; PT, post-treatment.

RESULTS

The analysis included 31 910 patients with incident colon cancer. There was an increase of cases over time. Almost two-thirds (63%) of patients were aged ≥70 years at diagnosis; a slightly higher proportion were men (52%) than women (table 1).

Receipt of cancer-directed surgery

There was a strong inverse association between age group and the OR for receiving surgery which became even stronger after adjustment for the covariates (table 2); compared with the <60 years age group the multivariable ORs were 0.84, 95% CI 0.74 to 0.95; 0.54, 0.48 to 0.61 and 0.19, 0.17 to 0.21, respectively (table 2). When the analyses were restricted to patients with stage I–III cancers, almost all (98.9%) of patients

Table 2 Likelihood (OR with 95% CI and p value from logistic regression) of receiving cancer-directed surgery* by age, and adjusted for sex, deprivation, time period, stage and comorbidity for patients with colon cancer

	Number (%) receiving surgery	Unadjusted (n=31 910)			Mutually adjusted (n=31 910)		
	n (%)	OR	95% CI	P† values	OR	95% CI	P† values
Age group, years				**<0.001**			**<0.001**
<60	3833 (84.1)	1.00			1.00		
60–69	6194 (84.0)	0.99	0.89 to 1.09	0.809	0.84	0.74 to 0.95	0.005
70–79	8802 (79.4)	0.73	0.66 to 0.80	<0.001	0.54	0.48 to 0.61	<0.001
80+	5434 (61.1)	0.30	0.27 to 0.32	<0.001	0.19	0.17 to 0.21	<0.001
Sex				**<0.001**			**0.052**
Female	11 332 (74.5)	1.00			1.00		
Male	12 931 (77.4)	1.18	1.12 to 1.24	<0.001	1.06	0.98 to 1.14	0.160
Deprivation quintile				**<0.001**			**<0.001**
1 (least deprived)	4574 (80.5)	1.00			1.00		
2	4797 (78.0)	0.86	0.79 to 0.94	0.001	0.91	0.81 to 1.04	0.158
3	4545 (75.9)	0.76	0.70 to 0.83	<0.001	0.76	0.67 to 0.86	<0.001
4	5008 (74.6)	0.71	0.65 to 0.78	<0.001	0.77	0.68 to 0.87	<0.001
5 (most deprived)	5339 (72.4)	0.63	0.58 to 0.69	<0.001	0.62	0.55 to 0.70	<0.001
Period of diagnosis				**<0.001**			**0.618**
1999–2002	7837 (79.5)	1.00			1.00		
2003–2006	7805 (74.9)	0.77	0.72 to 0.82	<0.001	0.80	0.72 to 0.87	<0.001
2007–2010	8621 (74.2)	0.74	0.69 to 0.79	<0.001	0.93	0.84 to 1.03	0.146
Stage				**<0.001**			**<0.001**
I	2751 (98.9)	1.00			1.00		
II	9028 (99.1)	1.29	0.85 to 1.96	0.235	1.39	0.91 to 2.11	0.123
III	7626 (98.6)	0.77	0.51 to 1.14	0.194	0.76	0.51 to 1.13	0.176
IV	3224 (41.8)	0.01	0.01 to 0.01	<0.001	0.01	0.00 to 0.01	<0.001
Unstaged	1506 (33.9)	0.01	0.00 to 0.01	<0.001	0.01	0.00 to 0.01	<0.001
Stage PT	128 (97.7)	0.48	0.15 to 1.59	0.231	0.34	0.10 to 1.15	0.083
CCM				**<0.001**			**0.041**
0	17 851 (79.4)	1.00			1.00		
1–2	2156 (72.5)	0.68	0.613 to 0.74	<0.001	0.83	0. 73 to 0.95	0.007
3+	443 (63.3)	0.45	0.38 to 0.52	<0.001	0.68	0.54 to 0.86	0.001
No HES link	3813 (66.3)	0.51	0.48 to 0.55	<0.001	0.71	0.64 to 0.79	<0.001

*Includes surgery +/-chemotherapy; overall 24 263 (76.0%) of 31 910 cases had surgery.
†P values in bold are from likelihood ratio tests of the contribution of the variable to the model. Unbolded P values are from a test of whether the OR is different from 1.
CCM, Charlson comorbidity index; HES, Hospital Episode Statistics; PT, post-treatment.

received surgery. Those in the oldest age group (80+ years) with stage I–III cancers were significantly less likely to receive surgery than those in the <60 years age group (OR=0.40, 95% CI 0.25 to 0.64). Overall, the likelihood of receiving surgery was lower in the two more recent time periods than in the period 1999–2002 but the 2006–2010 effect markedly attenuated after adjustment and was consistent with chance. There was no gender effect but patients from poorer areas were less likely to receive surgery. Comorbidity was associated with a reduced odds of surgery.

Receipt of chemotherapy in surgical patients

Similar age patterns in receipt of chemotherapy were seen, although the gradient was even more extreme (table 3). The likelihood of surgical patients receiving chemotherapy increased over time in a dose–response pattern. Men and patients with higher stage cancer were more likely to get chemotherapy while area deprivation was associated with a reduced likelihood. When analyses were repeated, restricted to stage III and IV cancers, to take into account that chemotherapy is not appropriate for early stage cancers, similar results were found (data not shown).

Receipt of chemotherapy in non-surgical patients

Increasing age was also strongly associated with reduced likelihood of receiving chemotherapy alone (OR=0. 43, 95% CI 0.35 to 0.52; 0.20, 0.17 to 0.24 and 0.03, 0.02 to 0.04 for the 60–69, 70–79 and 80+ year age groups, respectively, for the fully adjusted model) (table 4). Other covariates showed the same pattern as for chemotherapy among surgical patients with, again, a marked period effect. Similar results were found when only patients with stage III and IV cancers, for whom chemotherapy is recommended, were included in the analysis (data not shown).

Receipt of no treatment

Age inequalities were found in likelihood of not receiving any treatment (online supplementary web table 1). The OR for

Table 3 Likelihood (OR with 95% CI and p value from logistic regression) of receiving *chemotherapy in surgical patients** by age, and adjusted for sex, deprivation, time period, stage and comorbidity for patients with colon cancer

	Number (%) receiving chemotherapy	Unadjusted (n=24 263)			Mutually adjusted (n=24 263)		
	n (%)	OR	95% CI	P† values	OR	95% CI	P† values
Age group, years				**<0.001**			**<0.001**
<60	2264 (59.1)	1.00			1.00		
60–69	2854 (46.1)	0.59	0.55 to 0.64	<0.001	0.54	0.49 to 0.60	<0.001
70–79	2356 (26.8)	0.25	0.23 to 0.27	<0.001	0.19	0.17 to 0.21	<0.001
80+	262 (4.8)	0.04	0.03 to 0.04	<0.001	0.02	0.02 to 0.02	<0.001
Sex				**<0.001**			**0.126**
Female	3409 (30.1)	1.00			1.00		
Male	4327 (33.5)	1.17	1.11 to 1.23	<0.001	1.10	1.01 to 1.18	0.011
Deprivation quintile				**<0.001**			**<0.001**
1 (least deprived)	1620 (35.4)	1.00			1.00		
2	1658 (34.6)	0.96	0.88 to 1.05	0.386	1.08	0.96 to 1.20	0.201
3	1451 (31.9)	0.86	0.78 to 0.93	<0.001	0.92	0.82 to 1.03	0.142
4	1468 (29.3)	0.76	0.69 to 0.82	<0.001	0.81	0.72 to 0.91	<0.001
5 (most deprived)	1539 (28.8)	0.74	0.68 to 0.80	<0.001	0.72	0.65 to 0.80	<0.001
Period of diagnosis				**<0.001**			**<0.001**
1999–2002	2235 (28.5)	1.00			1.00		
2003–2006	2515 (32.2)	1.19	1.11 to 1.28	<0.001	1.36	1.24 to 1.49	<0.001
2007–2010	2986 (34.6)	1.33	1.24 to 1.42	<0.001	1.83	1.66 to 2.01	<0.001
Stage				**<0.001**			**<0.001**
I	39 (1.4)	1.00			1.00		
II	1442 (16.0)	13.2	9.59 to 18.2	<0.001	17.1	12.54 to 23.6	<0.001
III	4191 (55.0)	84.8	61.7 to 116.8	<0.001	155.9	109.8 to 210.1	<0.001
IV	1841 (57.1)	92.6	67.0 to 127.9	<0.001	137.3	98.7 to 191.0	<0.001
Unstaged	123 (8.2)	6.18	4.29 to 8.92	<0.001	5.48	3.78 to 7.95	<0.001
Stage PT	100 (78.1)	248.4	146.9 to 419.8	<0.001	216.0	122.5 to 380.9	<0.001
CCM				**0.506**			**<0.001**
0	5935 (33.3)	1.00			1.00		
1–2	414 (19.2)	0.48	0.43 to 0.53	<0.001	0.53	0.46 to 0.61	<0.001
3+	59 (13.3)	0.31	0.23 to 0.41	<0.001	0.30	0.21 to 0.41	<0.001
No HES link	1328 (34.8)	1.07	1.00 to 1.15	0.061	0.89	0.79 to 0.99	0.043

* Includes only patients who had surgery, n=24 263, of whom 7736 (31.9%) had chemotherapy
† P values in bold are from likelihood ratio tests of the contribution of the variable to the model. Unbolded P values are from a test of whether the OR is different from 1.
CCM, Charlson comorbidity index; HES, Hospital Episode Statistics; PT, post-treatment.

receipt of no treatment in those aged 60–69 years was 1.98 (95% CI 1.69 to 2.32) increasing to 15.4 (13.2 to 17.9) in those aged 80+ years, in the fully adjusted model.

Time trends in colon cancer treatment

Figure 1A shows that the difference in the ORs for receipt of surgery for patients aged 60–69 years and 70–79 years compared with those aged <60 years diminished over time. However, the change in the OR for patients aged 80+ years was much less marked (OR=0.23, 0.18 to 0.29; 0.19, 0.15 to 0.24 and 0.16, 0.13 to 0.20 for the three time periods, respectively). Significant interactions were found between age and period of diagnosis for receipt of surgery (p=0.010) and receipt of chemotherapy in surgical (p=0.001), but not in non-surgical (p=0.807), patients, suggesting that the relationship between receipt of treatment and age has changed over time (online supplementary web figure).

In all time periods, surgical patients in the older age groups remained less likely to receive chemotherapy than those in the <60 years group (figure 1B). However, the difference in the ORs was smaller in 2007–2010 than in 1999–2002 for those in the 60–69 year and 70–79 year age groups. There was no change in the 80+ year age group. The likelihood of receiving chemotherapy alone remained constant within each of the age groups over the time periods observed (figure 1C). The likelihood of receiving no treatment decreased somewhat over time in the 60–69 year age group, but increased in the 80+ year age group (OR=11.1, 8.3 to 14.7; 15.4, 11.9 to 20.0 and 19.2, 14.9 to 24.7 for the three time periods, respectively) (figure 1D).

DISCUSSION

Main findings

Age inequalities in the receipt of colon cancer-directed surgery, chemotherapy in surgical patients and chemotherapy in non-surgical patients were apparent in this population-based registry study, after adjustment for factors likely to be associated with

Table 4 Likelihood (OR with 95% CI and p value from logistic regression) of receiving *chemotherapy in non-surgical patients** by age, and adjusted for sex, deprivation, time period, stage and comorbidity for patients with colon cancer

	Number (%) receiving chemotherapy	Unadjusted (n=7647)			Mutually adjusted (n=7647)		
	n (%)	OR	95% CI	P† values	OR	95% CI	P† values
Age group, years				**<0.001**			**<0.001**
<60	450 (62.2)	1.00			1.00		
60–69	500 (42.3)	0.44	0.37 to 0.54	<0.001	0.43	0.35 to 0.52	<0.001
70–79	520 (22.8)	0.18	0.15 to 0.21	<0.001	0.20	0.17 to 0.24	<0.001
80+	119 (3.4)	0.02	0.02 to 0.03	<0.001	0.03	0.02 to 0.04	<0.001
Sex				**<0.001**			**<0.001**
Female	607 (15.6)	1.00			1.00		
Male	982 (26.1)	1.90	1.70 to 2.13	<0.001	1.40	1.22 to 1.61	<0.001
Deprivation quintile				**<0.001**			**<0.001**
1 (least deprived)	320 (28.9)	1.00			1.00		
2	304 (22.5)	0.71	0.59 to 0.86	<0.001	0.79	0.63 to 0.99	0.037
3	316 (21.9)	0.69	0.58 to 0.83	<0.001	0.67	0.54 to 0.84	<0.001
4	316 (18.6)	0.56	0.47 to 0.67	<0.001	0.62	0.50 to 0.78	<0.001
5 (most deprived)	333 (16.3)	0.48	0.40 to 0.57	<0.001	0.44	0.36 to 0.55	<0.001
Period of diagnosis				**<0.001**			**<0.001**
1999–2002	331 (16.4)	1.00			1.00		
2003–2006	559 (19.8)	1.26	1.09 to 1.47	0.003	1.42	1.18 to 1.70	<0.001
2007–2010	739 (24.6)	1.67	1.44 to 1.93	<0.001	2.42	2.01 to 2.90	<0.001
Stage				**<0.001**			**<0.001**
I	2 (6.5)	1.00			1.00		
II	9 (11.4)	1.86	0.38 to 9.16	0.443	2.15	0.41 to 11.4	0.369
III	43 (38.4)	9.04	2.05 to 39.8	0.004	7.10	1.50 to 33.9	0.014
IV	1406 (31.3)	6.61	1.58 to 27.8	0.100	4.20	0.94 to 18.7	0.060
Unstaged	126 (4.3)	0.65	0.15 to 2.76	0.560	0.72	0.16 to 3.25	0.671
Stage PT	3 (100.0)	–					
CCM				**<0.001**			**<0.001**
0	1172 (25.3)	1.00			1.00		
1–2	100 (12.2)	0.41	0.33 to 0.51	<0.001	0.68	0.55 to 0.87	0.002
3+	19 (7.4)	0.24	0.15 to 0.38	<0.001	0.30	0.18 to 0.51	<0.001
No HES link	298 (15.4)	0.54	0.47 to 0.62	<0.001	0.60	0.50 to 0.72	<0.001

*Includes only patients who didn't have surgery, n=7647, of whom 1589 (20.8%) had chemotherapy.
† P values in bold are from likelihood ratio tests of the contribution of the variable to the model. Unbolded P values are from a test of whether the OR is different from 1.
CCM, Charlson comorbidity index; HES, Hospital Episode Statistics; PT, post-treatment.

the appropriateness of providing treatment, including stage and comorbidity. These differences persisted over time. We identified an interaction between age and time period of diagnosis associated with receipt of treatment. This suggested a narrowing of the treatment gap during the period 1999–2010 between those aged <60 years and those aged less than <80 years, but no change in the treatment gap between those aged <60 years and the oldest (aged ≥80 years and older) patients.

Strengths of this study

The strengths of this study are the use of a population-based registry, linked to NHS HES data. The NYCRIS has been found to have excellent population coverage.[20] This meant we have robust data on cases of colon cancer, treatment received and information on potential confounding factors. In contrast to many other studies that have examined the relationship between age and receipt of treatment for colon cancer and failed to adjust for comorbidity, data on comorbidity were available for patients included in this study.

Weaknesses of this study

Data included in this study were from the north of England. This potentially reduces the generalisability of our findings to other settings. As is common in population-based datasets, a notable proportion of patients (14% overall) were unstaged. While this could be due to a failure by the registry to record staging information, the low percentage of unstaged patients who were treated, and the increase in percentage unstaged by age (24% in the 80+ age group compared with 8% in the youngest age group), suggests that it is more likely to be because these patients were simply too unwell to be staged. Even in this large dataset, some subgroups were relatively small and had few events meaning that the ORs were very small or large. However, we would suggest that the precise risk estimates are not the most important aspect

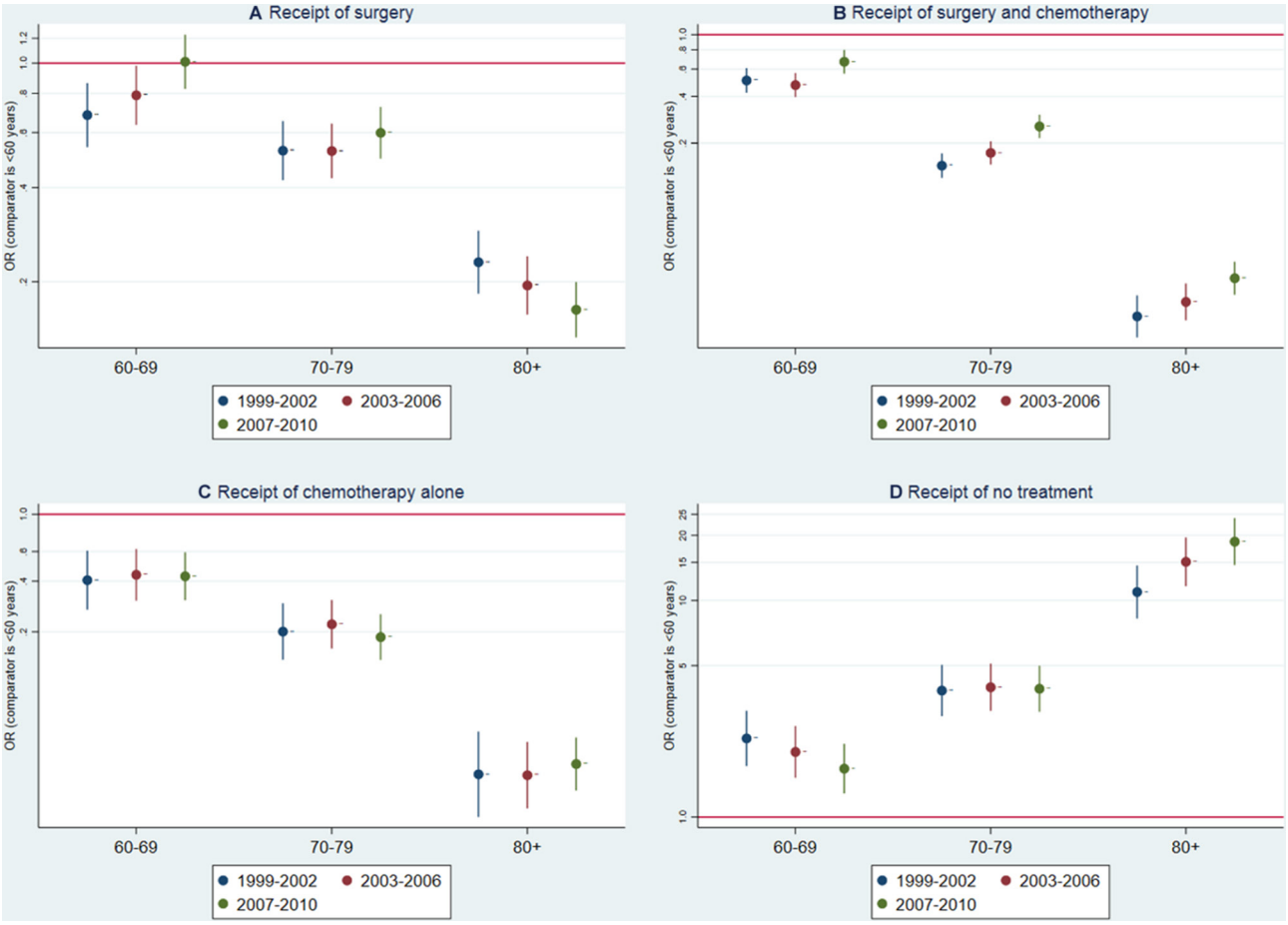

Figure 1 ORs (with 95% CIs) for receipt of colon cancer directed treatment by age group, over time, adjusted for sex, deprivation, stage and comorbidity.

of our results; rather the importance lies in the observed pattern of treatment receipt by age.

We had information on treatment receipt and, for chemotherapy and radiotherapy this is, in effect, whether an individual started a course of treatment. A limitation is that we did not know whether they completed the course; some studies suggest that a significant proportion of patients cannot complete treatment due to toxicity.[21] Although we took account of comorbidity in our analyses, the Charlson comorbidity index[19] that we used to identify comorbidities captures information only on conditions that require an inpatient stay. It is possible, therefore, that individuals who had a score of zero recorded for comorbidity suffered from conditions that would be included in the index, but received all their care in primary care or as outpatients. It is also the case that patients with different severity of comorbid diseases receive the same score, making it a somewhat crude measure. In addition, the CCM was not designed to detect frailty, which is common in older individuals and is an important consideration when determining appropriate treatment for colon cancer given the physical burden associated with cancer treatment.[12] It is very likely that we have underestimated true levels of comorbidity in the study population and failed to fully control for confounding by health status. Thus, it remains possible that the observed trends in treatment receipt by age could be a result, at least in part, of valid clinical decisions based on the patient's overall health and likely ability to withstand treatment. As is usual with registry data, we did not have information on whether treatment was given with curative or palliative intent. In addition, patient and family preferences around quality of life can also influence treatment decisions and as this is not recorded, we were unable to take these factors into account in our analyses.

We note that, despite those in the oldest age group with a stage I–III cancer being significantly less likely to receive surgery than those in the youngest age group, the number in this age group not receiving surgery was small (n=98 patients; 2%) and this might be accounted for by sound clinical reasons not to offer surgery to these individuals.

Interpretation of findings

Age-related inequalities in the treatment of colon cancer have previously been reported. In particular, it has been noted that older people with colon cancer typically receive less adjuvant chemotherapy than younger individuals and that the likelihood of receiving adjuvant chemotherapy decreases with age.[22] Putative reasons for this include that evidence for the effectiveness of adjuvant chemotherapy in older populations is lacking.[23] More good quality trials of different treatment options in the elderly population on which evidence-based treatment decisions can be made are needed.[10] Where trials in elderly and frail populations have been attempted, successes have been reported. The MRC FOCUS2 trial, an open factorial trial, designed to

examine reduced dose chemotherapy in elderly and frail patients (median age of 74 years) with advanced colorectal cancer, demonstrated that these patients can be included successfully in randomised controlled trials and that age and frailty should not preclude individuals from participation in research.[24]

Previous work has suggested that clinicians rely too much on chronological age rather than an assessment of biological age and capacity to withstand treatment when making decisions about how to treat patients with cancer.[25] The difficulty of, and resources needed for, evaluating the vulnerability of elderly people to cancer treatment using the comprehensive geriatric assessment (CGA) has been acknowledged. Frailty screening methods to negate the need for the CGA to be used to assess all elderly patients have been proposed, but none has yet proved to be satisfactorily able to discriminate between those who are robust and should receive standard cancer treatment and those who should receive a CGA.[12] Current guidance remains that all elderly people should receive a CGA to inform treatment decisions.

When we considered whether or not inequalities in receipt of treatment had changed over time, we found some evidence that the treatment gap between those aged <60 years and the 'younger old' (aged <80 years) had narrowed to some extent, but that there was no evidence of a narrowing of the treatment gap for the oldest old. This might reflect accumulating trial evidence suggesting that the benefit of adjuvant chemotherapy is independent of age, at least up to the age of 79 years, but that data on the oldest old are lacking.[26] In a pooled analysis of adjuvant chemotherapy for 3351 patients with resected colon cancer, 14% of included patients were aged 70–79 years but <1% were aged ≥80 years, leading the authors to conclude that extrapolation to the oldest age group should be made with caution.[26]

Within the UK, there is increasing interest in ensuring that the elderly receive appropriate cancer treatment. Action for the elderly in cancer was identified as a main priority at the Britain Against Cancer Conference in 2013.[7] The National Cancer Equality Initiative, in collaboration with the Pharmaceutical Oncology Initiative (NCEI-POI), is a UK-wide effort to challenge ageism in cancer care. NCEI-POI seeks to better understand how treatment decisions are made in relation to cancer care for older people and to identify how more personalised treatment plans can be developed.[27] It is important that the fitness of the individual patient, the potential benefit they might gain from different treatment regimens and patients', and their family's, perspectives on treatment should all be taken into account when designing an optimum care plan.

It was noted in a recent report published by The Royal College of Surgeons of England that existing national guidance does not make specific recommendations on how to treat older patients with colon cancer, and concluded that 'all reasonable curative treatment options' should be explored.[28] Since it is extremely unlikely that the age-disparities in treatment that we have observed can be explained by patient or family preference, our data suggest that 'all reasonable curative options' are still not being explored. It should be acknowledged, however, that there remains a lack of good quality research into the treatment of elderly patients with colon cancer to inform treatment options.[27] This, together with further research to better understand the treatment decision-making process, and how to influence this, is urgently needed.

While the focus of our enquiries was on age equity, our results also demonstrated marked effects by area deprivation, and for chemotherapy, there were also gender differences. These are also important in terms of equitable access and appear to have independent effects so that older women in deprived areas would be least likely to receive some interventions.

Colon cancer is common in older people, with 43% of cases diagnosed in people aged ≥75 years in the UK between 2009 and 2011.[1] Current demographic changes leading to an increasingly older population means the number of individuals diagnosed with colon cancer is likely to increase. There is a need for work both to identify the most effective treatment for colon cancer in older populations and to understand clinicians' decision-making processes to ensure equitable access.

What is already known on this subject

- Older individuals have poorer survival from colon cancer than younger individuals.
- Inequalities in access to appropriate colon cancer treatment might account for this poorer survival.

What this study adds

- Older age is associated with lower likelihood of receiving colon cancer-directed surgery and adjuvant therapy, and greater likelihood of receiving no cancer-directed treatment, after adjustment for confounding factors.
- There is evidence that the treatment gap between the youngest patients and the 'younger old' decreased between 1999 and 2010.
- There was no narrowing of the treatment gap between the youngest patients and the 'oldest old' during this period.

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